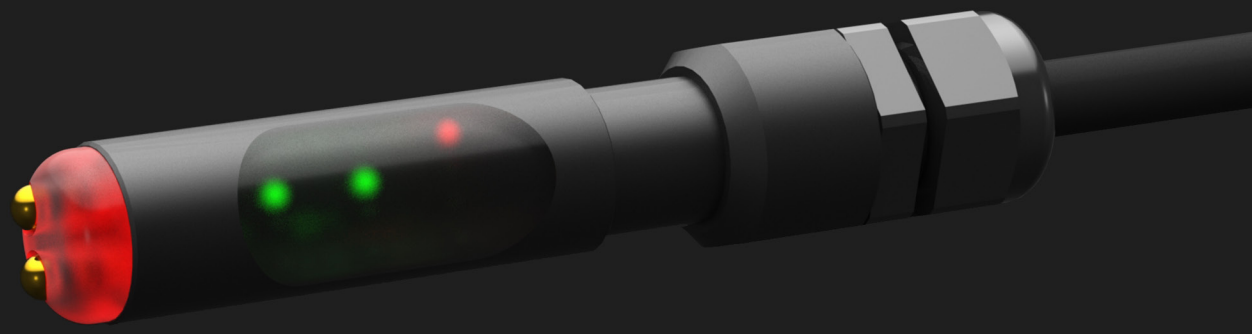
SHEARWATER HUD



User Manual

DiveCAN®

Heads-Up Display (HUD)

SHEARWATER

Powerful • Simple • Reliable

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DANGER

This device displays partial pressure of oxygen (PPO2). Knowing the loop PPO2 when diving a rebreather is critically important at all times. Do not base your knowledge of loop PPO2 solely on this device. Always dive with a backup PPO2 monitor.

This device communicates PPO2 using a series of blinks that are either color dependent or position dependent. Do not attempt to decipher the blink pattern without reading this manual. Do not use this device if you are not confident in your ability to read the PPO2.

Rebreather diving is a high-risk activity. Understand the risks. Know how and why PPO2 measurements can be wrong. Have a plan to identify and deal with problems in the PPO2 measurement and display system.

You really are risking your life with this activity.

WARNING

This device will fail.

It is not whether it will fail but when it will fail. Do not depend on it. Always have a plan on how to handle failures. Automatic systems are no substitute for knowledge and training.

Never risk your life on only one source of information. Always use a backup PPO2 measurement and display system. If you choose to make riskier dives, obtain the proper training and work up to them slowly to gain experience.

No technology will keep you alive. Knowledge, skill, and practiced procedures are your best defense (except for not doing the dive, of course).

1. Introduction

The Shearwater DiveCAN® Heads-Up Display (HUD) is a rebreather partial pressure of oxygen (PPO2) display device.

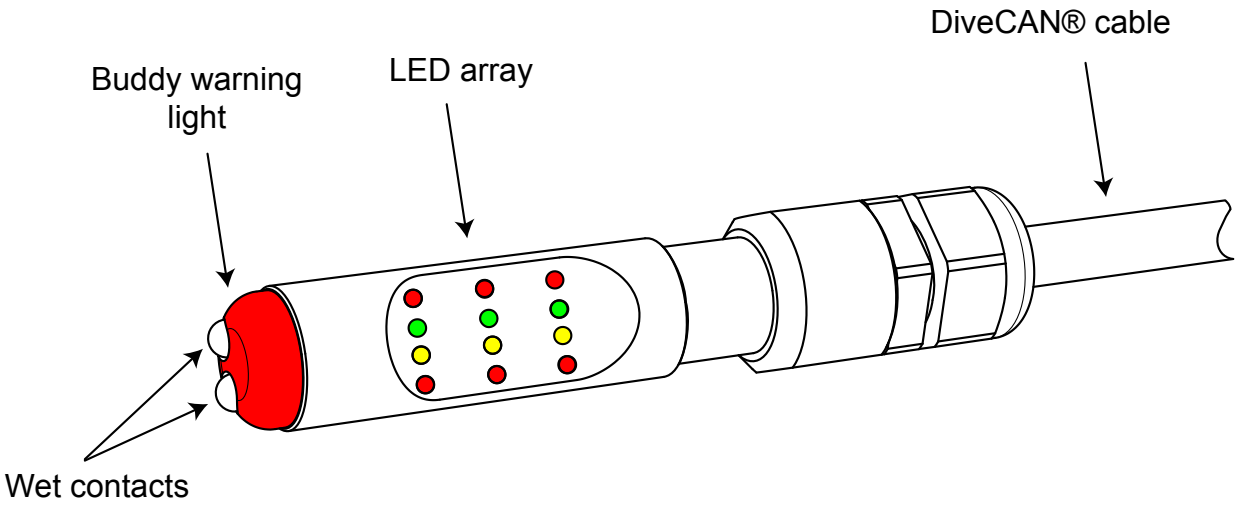
Please take the time to read this manual.

Your life depends on always knowing the loop PPO2 when diving a rebreather. Please do not make assumptions about how this device works, even if you have used a previous generation of Shearwater HUD. Some of the blink patterns and warnings have changed.

1.1 Features

- PPO2 display from 3 oxygen sensors.
- Modified Smither's code blink pattern.
- Bright light emitting diodes with vibrant colors.
- Color-blind blink pattern (optional setting).
- Wet contacts for automatic turn-on and user commands.
- Option to flip orientation - can be positioned on either side of the rebreather mouthpiece.
- DiveCAN® communications interface for robust data transmission and easy upgrades, disassembly and repairs.
- Bright red end-cap LED for buddy warnings.
- Automatic brightness control optimizes viewing in all conditions.
- Red color only used for unsafe PPO2 warnings.

2. Physical Description



LED array

An array of colored light emitting diodes (LEDs) blink to display PPO2.

For color-blind users, there is an optional blink pattern that uses position only to display PPO2.

Buddy warning light

The buddy warning light pulses when PPO2 is outside a safe range.

Wet contacts

Putting the wet contacts in water or touching them with a wet finger will turn on the HUD. The wet contacts are also used to enter commands.

DiveCAN® cable

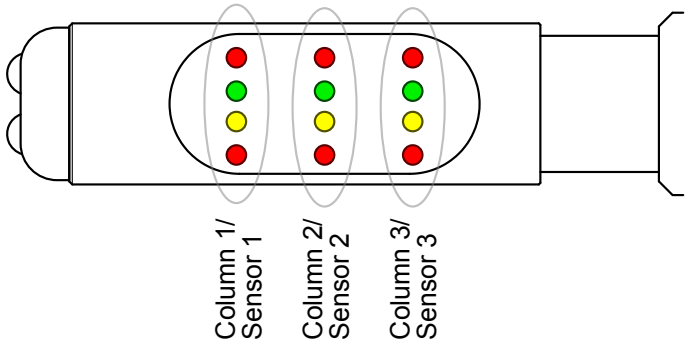
The DiveCAN® cable provides a robust, disconnectable connection to the rebreather.

3. Reading the PPO2

The default blink pattern is a modified Smither's code, similar to the previous generation Shearwater HUD. See Section 6.1 for the optional color-blond mode.

A few definitions first.

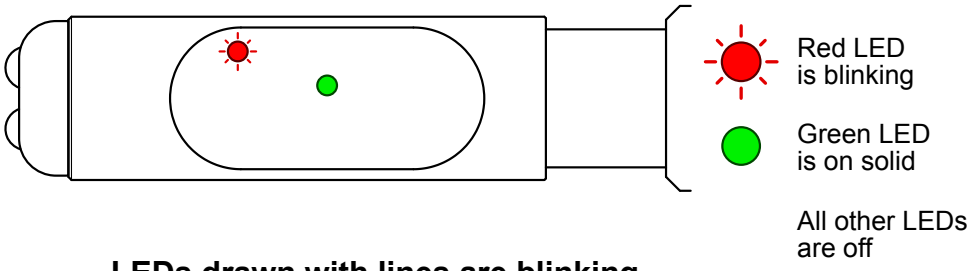
Units: PPO2 is displayed in absolute atmospheres (ata) with a resolution of 0.1ata. For the purposes of this HUD, this can be considered the same as Bar. i.e. 1 ata ≈ 1 Bar.



Each column displays PPO2 from one O2 Sensor

There are four rows of LEDs. Top is red. Next is green, then yellow. Bottom row is red.

A blinking LED is drawn with lines emanating from it.
An LED that is on-steady is drawn solid. An off LED is not drawn.



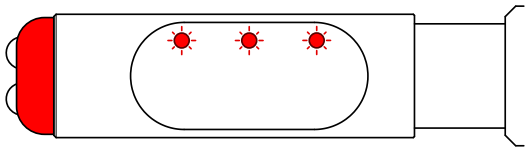
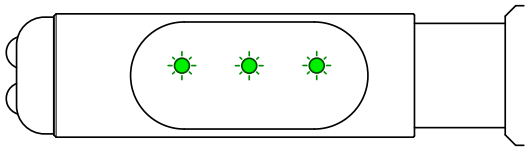
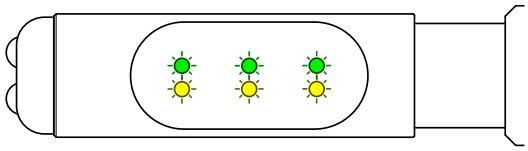
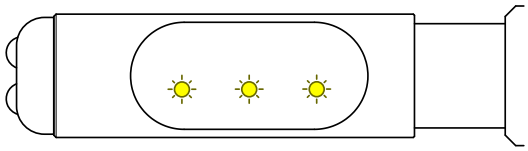
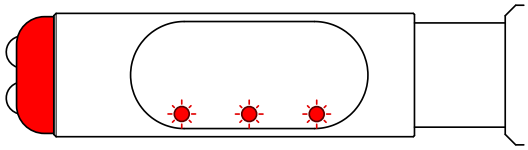
LEDs drawn with lines are blinking

3.1 Modified Smither's Code

This is the default blink pattern. Blinks of color are used to display PPO2.

Every 5 seconds a blink cycle begins.

The blink pattern depends on the PPO2 range:

PPO2 Range	HUD Display	Blink Pattern
Above 1.6		Top-red blinks once for each 0.1 above 1.0 e.g. 1.7 = 7 top-red blinks
1.1 to 1.6		Green blinks once for each 0.1 above 1.0 e.g. 1.3 = 3 green blinks
1.0		1.0 = Green and yellow blink once together.
0.4 to 0.9		Yellow blinks once for each 0.1 below 1.0 e.g. 0.7 = 3 yellow blinks
Below 0.4		Bottom-red blinks once for each 0.1 below 1.0 e.g. 0.2 = 8 bottom-red blinks

The above can be summed up as:

- Top-red blinks above 1.6
- Green blinks once for each 0.1 above 1.0
- Green and yellow blink together once for 1.0
- Yellow blinks once for each 0.1 below 1.0
- Bottom-red blinks below 0.4

3.2 Detecting Abnormal PPO2

The modified Smither's code has some nice attributes that grab attention in abnormal or unsafe situations.

PPO2 deviations from setpoint

A typical rebreather PPO2 setpoint will be about 0.7 to 0.8 for the low setpoint, and 1.2 to 1.3 for the high setpoint.

Therefore, when the loop is at setpoint, you will expect to see 2 to 3 blinks per 5 second cycle.

If the "light density" changes (i.e. you are seeing more or less blinks), then the setpoint is off target.

This change in light density can grab your attention even if you have tuned out the blinking of the LEDs. Of course, we recommend paying attention at all times.

Unsafe PPO2

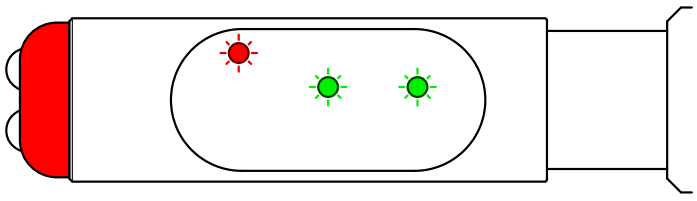
If the PPO2 falls below 0.4 or rises above 1.6, you will be seeing a lot of red blinking.

Since red is not used at all in the normal safe PPO2 range, the presence of red is a clear signal that something is wrong.

Buddy red warning light

The sole function of the buddy red warning light is to alert that the PPO2 is outside the range of 0.4 to 1.6. If any O2 cell is outside this range then the warning light turns on.

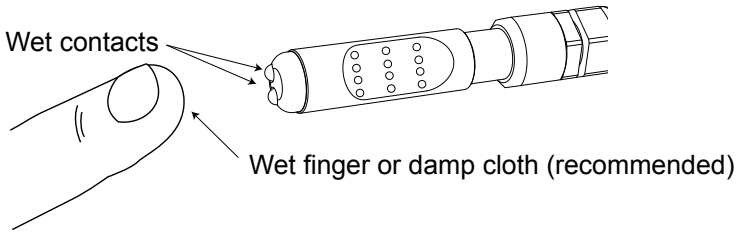
If the buddy warning light comes on, check your PPO2, consult your handset, and deal with the problem.



The buddy warning light comes on if <u>any</u> O2 sensor is unsafe

4. Basic Commands

Commands are entered using the wet contacts.



Activate the wet contacts by connecting them with a conductive material.

This can be:

- A damp cloth (recommended)
- A wet finger
- Water
- A coin
- A piece of metal, etc.

The basic commands are:

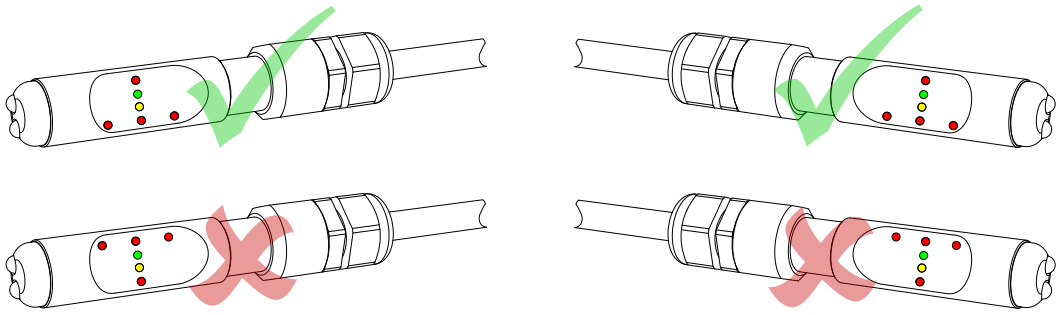
- Turn-on
- Enter advanced menu
- Turn-off
- PPO2 Calibration

4.1 Turning On

Turn the HUD on by holding the wet contacts. **It may take <u>up to 5 seconds</u> to turn on. <u>Keep holding</u> until the LEDs turn on.**

After turning on, each LED will light up briefly. Use this time to verify that each LED, including the buddy warning light, works properly. **Do not use the HUD if any LED is not working.**

After each LED has been turned on, an “UP” arrow will briefly display. This indicates which orientation the HUD has been set to use.



After turning on, orient the HUD so that the arrow points up

4.2 Entering Commands

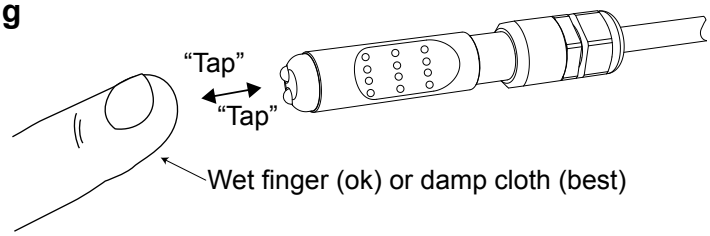
A command is entered by:

1) Double tapping the wet contacts to select a command column.

2) Holding the wet contacts for 3 seconds to confirm the command.

3) The LEDs blink twice to show the command was accepted. The wet contacts must be released during these two blinks or the command will be ignored.

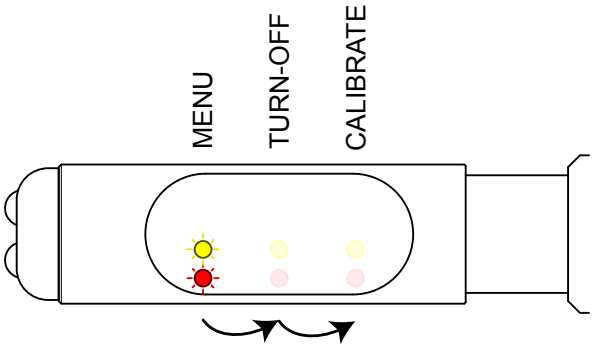
Tips for Tapping



It should take about 1 second to complete the double-tap. Too fast or too slow will be ignored. Saying "tap-tap" aloud at a normal pace will help get the timing right.

A damp cloth works best for tapping. This is because a connection must be made then broken each tap. A wet finger or dipping in water can cause a droplet of water to cling between the contacts, preventing the break. A damp cloth works best for clearing this droplet and therefore should be damp but not soaking wet.

After the first double-tap, the bottom two LEDs of column 1 will blink. This is "command column 1" or the MENU command. Each double-tap advances the command column.



Each double-tap advances the command column by one position

When the desired command is blinking, hold the wet contacts for 3 seconds to execute the command. The LED column will blink 2 times as a confirmation. During these 2 blinks the wet contacts must be released, or the command is ignored. This is to prevent submerging at the start of a dive from accidentally executing a command.

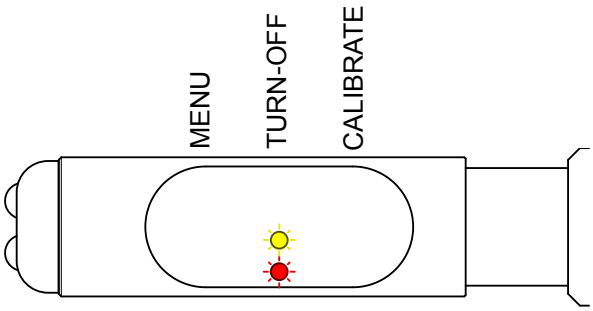
4.3 Menu Command

The menu command will be explained further in the Section 6 “Advanced Options”.

The Advanced Options menu is entered by holding for 3 seconds while on command column 1. This command must be executed three times to enter the advanced options menu. The three times executing the command prevents accidental changing of options.

4.4 Turn-Off Command

Turn off by holding the wet contacts for 3 seconds while on command column 2.



Hold wet contacts on command column 2 to turn-off

The complete turn off sequence is:

1. Double-tap to enter 1st command column (MENU).
2. Double-tap again to advance to 2nd command column (TURN OFF).
3. Hold for 3 seconds.
4. While holding, the 2nd column LEDs count up. They blink twice to confirm the command. The wet contacts must be released during these 2 blinks.
5. HUD shuts off.

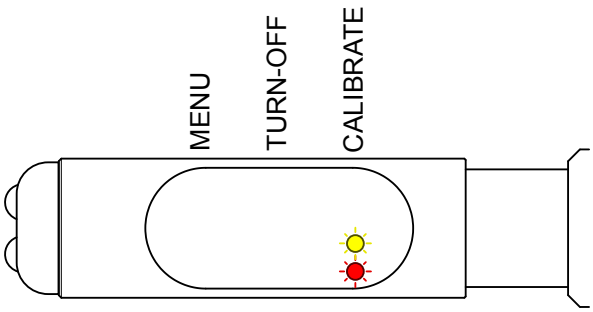
Turn off the HUD when not in use to save battery power.

The HUD will turn off by itself after 30 minutes of inactivity.

However, the HUD will not turn-off if the wet contacts detect the presence of water. Ensure the wet contacts are dry before putting the HUD into storage.

4.5 Calibrate (PPO2) Command

Perform the PPO2 calibration by holding the wet contacts for 3 seconds while on command column 3.



Hold wet contacts on command column 3 to calibrate

The complete calibration sequence is:

1. Follow the rebreather manufacturers instructions to flood the loop with pure oxygen.
2. Double-tap to enter 1st command column (MENU).
3. Double-tap again to advance to 2nd command column (TURN OFF).
4. Double-tap again to advance to 3rd command column (CALIBRATE).
5. Hold for 3 seconds.
6. While holding, the 3rd column LEDs count up. They blink twice to confirm the command. The wet contacts must be released during these 2 blinks.
7. The green and yellow LED rows then count up to indicate the calibration is in progress.
8. Once the calibration completes, the HUD will return to the regular PPO2 display.

The HUD only calibrates at a PPO2 of 1.0 ata. This means it assumes pure oxygen is used for the calibration, and it is performed at sea-level.

PPO2 Calibration at Altitudes Above Sea-Level

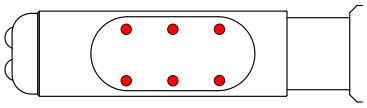
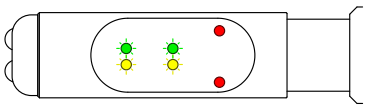
The calibration result is not stored in the HUD, but in the rebreather electronics to which the HUD connects, allowing for altitude calibration.

To calibrate at altitude, unplug the HUD DiveCAN® cable and temporarily replace the HUD with a device that can calibrate at altitude (for example a Petrel handset). Perform the calibration with the alternate device, and then switch the devices back to their proper connections.

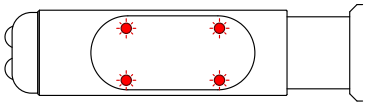
5. Error Displays

The following error conditions may occur:

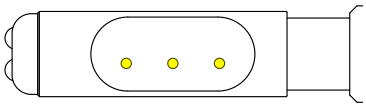
5.1 Failed PPO2 Calibration

HUD Display	Description	Troubleshooting
 Top and bottom red LEDs on solid	All O2 sensors have failed calibration	A good O2 sensor is expected to output between 30mV to 70mV in pure oxygen at sea-level. A sensor that does not meet these specs fails calibration. Fix the problem (e.g. replace the sensors) and recalibrate.
 Top and bottom red LEDs on solid (1 column) Other columns normal	One O2 sensor has failed calibration. In this case sensor #3 has failed.	It is possible for some sensors to pass calibration, while others fail. This indicates which sensor is faulty. See above for troubleshooting. **Do not dive unless all sensors are functional.**

5.2 No Communications

HUD Display	Description	Troubleshooting
 Four corners blinking	No DiveCAN® Communications	Ensure the DiveCAN® cable connector is securely fastened. Contact Shearwater or your rebreather manufacturer for service.

5.3 Low Battery

HUD Display	Description	Troubleshooting
 After turn on, the yellow row stays on for 30 seconds	Battery is low and should be replaced	Replace the battery (or batteries) for the monitoring/HUD electronics. See the instructions for your rebreather for battery type and location.

A note on the battery system:

The HUD does not have its own battery. It receives power from electronics located inside the rebreather.

A typical rebreather will have two independent battery systems. One battery system for the primary oxygen controller side, and one battery system for the backup monitoring side. This HUD is usually part of the backup monitoring side.

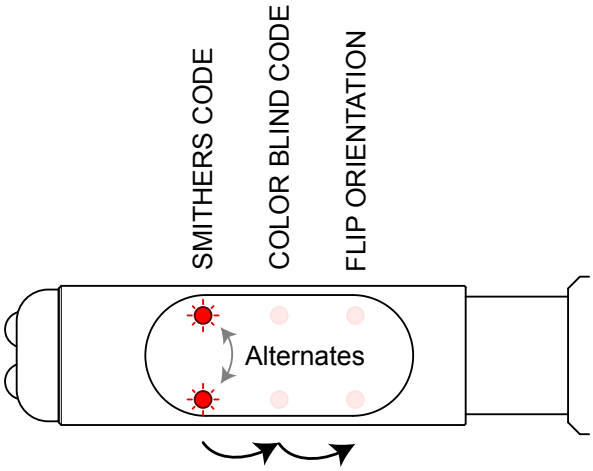
Different rebreathers use different battery types and configurations. Therefore, the HUD does not set a specific voltage at which the battery should be changed. The HUD just receives a message from the rebreather electronics that says the battery is low and should be changed.

Please read and follow the instructions for your rebreather on how to change the battery.

6. Advanced Options

There are two options that can be set by the user. 1) Choosing the PPO2 blink pattern. 2) Flipping the orientation to the other side of the rebreather mouthpiece.

Enter the Advanced Options menu by executing the MENU command 3 times. Once in the Advanced Options menu, the 1st column will alternately blink the top-red and bottom-red LEDs.



Each double-tap advances the option column by one position

Select the option by holding for 3 seconds while the option column is blinking.

An option column will time-out, returning to the regular PPO2 display after 20 seconds of inactivity. Also, double-tapping when on the last option column will return to the regular PPO2 display.

The options are:

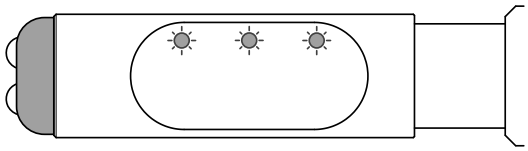
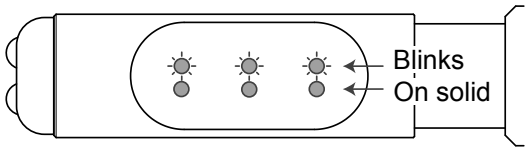
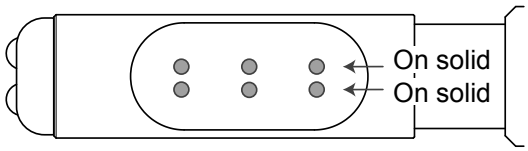
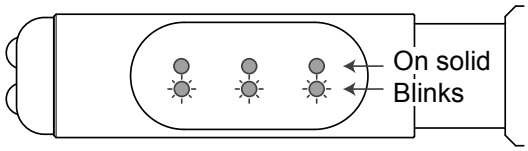
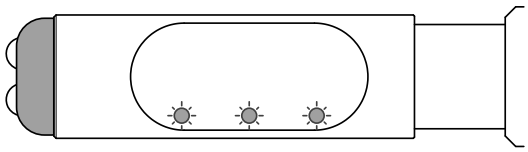
Column	Option Name	Description
1	SMITHER'S CODE	Set the blink pattern to the modified Smither's code. See Section 3.1
2	COLOR BLIND CODE	Set the blink pattern to the color blind mode. See Section 6.1
3	FLIP ORIENTATION	Flip so HUD can be put on other side of mouthpiece. See Section 6.2 Execute again to flip back.

6.1 Color Blind Code

The optional color blind blink pattern uses positioning of the LEDs to indicate PPO2.

Every 5 seconds a blink cycle begins.

The blink pattern depends on the PPO2 range:

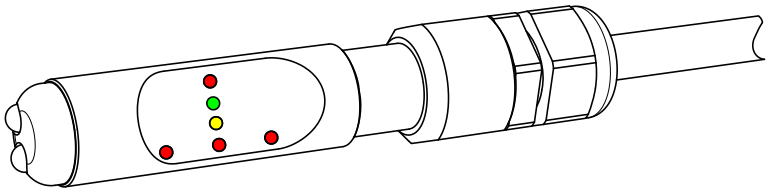
PPO2 Range	HUD Display	Blink Pattern
Above 1.6		Top row blinks once for each 0.1 above 1.0 e.g. 1.7 = 7 top row blinks
1.1 to 1.6		Upper-middle blinks once for each 0.1 above 1.0 Lower-middle row on solid e.g. 1.3 = 3 upper-middle blinks
1.0		1.0 = both middle rows on solid
0.4 to 0.9		Upper-middle row on solid Lower-middle blinks once for each 0.1 below 1.0 e.g. 0.7 = 3 lower-middle blinks
Below 0.4		Bottom row blinks once for each 0.1 below 1.0 e.g. 0.2 = 8 bottom row blinks

Key points:

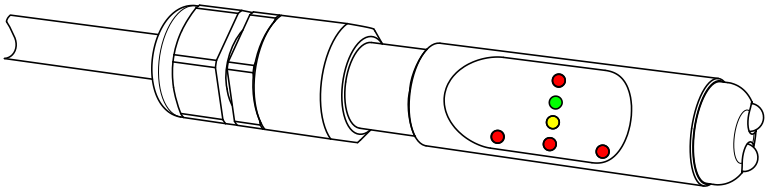
- Blinks above = above 1.0. Blinks below = below 1.0.
- If nothing solid on, then outside safe PPO2 range.

6.2 Flip Orientation

The orientation can be flipped so that the HUD can positioned on either side of the rebreather mouthpiece.



The default orientation has the cable exit to the right



Use the Advanced Option column 3 option to flip the HUD (cable now exits to left)

Flipping the HUD reorders the sensors such that sensor #1 is always viewed as the left-most column.

When the Smither's code is used and the HUD is flipped, the colors remain the same. That is, green blinks for above 1.0, yellow blinks for below 1.0.

If you have normal color vision, you will notice that when color-blind code is used and the HUD is flipped, the green and yellow colors swap. This is because position is what is conveying the information. That is, upper-middle row blinks when above 1.0, and the lower-middle row blinks when below 1.0.

7. Storage and Maintenance

The HUD should be stored clean and dry.

Do not allow salt deposits to build up on your HUD. Wash with fresh water to remove salt and other contaminants. **Do not use detergents or other cleaning chemicals** as they may damage the plastics and seals. Allow to dry naturally before storing.

Keep the wet contacts dry, as they will prevent the HUD from powering down if wet.

Store the HUD out of direct sunlight in a cool, dry and dust free environment. Avoid prolonged exposure to direct ultra-violet radiation and radiant heat.

There are no user serviceable parts inside the HUD. Do not attempt to disassemble.

Service of the HUD may only be done at Shearwater Research, or by any of our authorized service centers.

Your nearest service center can be found at www.shearwaterresearch.com/contact

8. Specifications

Specification	DiveCAN® HUD
Function	PPO2 Display
PPO2 range	0.1 ata to 1.9 ata
PPO2 resolution	0.1 ata
Crush Depth Limit	30 ata (~290msw)
Operating Temperature Range	+4ºC to +32ºC
Short-Term (hours) Temperature Range	-20ºC to +50ºC
Long-Term Storage Temperature Range	+5ºC to +20ºC
Power source	Supplied by DiveCAN® bus. 3.0V to 10.0V
External Connector	5-pin DiveCAN® connector (male pins)
Cable Length	1m
Weight	0.08kg
Size - body only (L X D)	84mm X 13.25mm

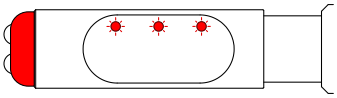
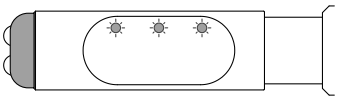
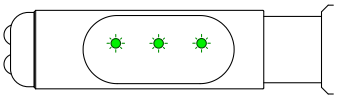
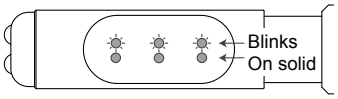
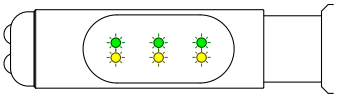
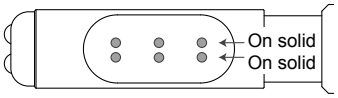
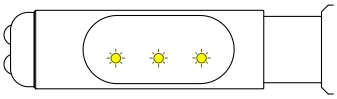
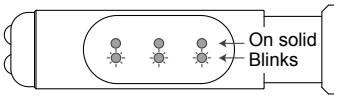
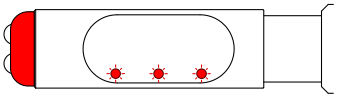
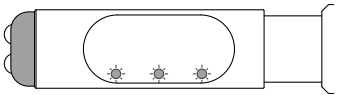
Appendix A - Quick Reference Card

Print out this card (2 sides) as a quick reference for the HUD displays and commands. Print at 75% scale for a compact option.

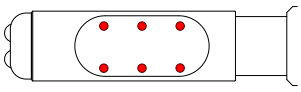
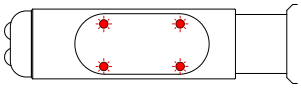
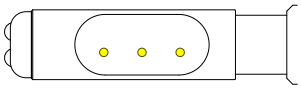
Quick Reference Card

SHEARWATER HUD

PPO2 Display:

PPO2 (ata)	Modified Smither's (default)	Color Blind Option
Above 1.6	 Top-red blinks each 0.1 above 1.0	 Top row blinks each 0.1 above 1.0
1.1 to 1.6	 Green blinks each 0.1 above 1.0	 Middle-top blinks each 0.1 above 1.0
1.0	 Green & Yellow blink once	 Both middle rows on solid
0.4 to 0.9	 Yellow blinks each 0.1 below 1.0	 Bottom-middle blinks each 0.1 below 1.0
Below 0.4	 Bottom-red blinks each 0.1 below 1.0	 Bottom row blinks each 0.1 below 1.0

Error Display:

Display	Display Description	Error Description
	Top and bottom red LEDs on solid	Sensor has failed PPO2 calibration. One or more columns may display this error.
	Four corners blinking	No communications with O2 sensor electronics
	After turn on, the yellow row stays on for 30 seconds	Battery is low and should be changed

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Appendix A - Quick Reference Card (continued)

Quick Reference Card

SHEARWATER HUD

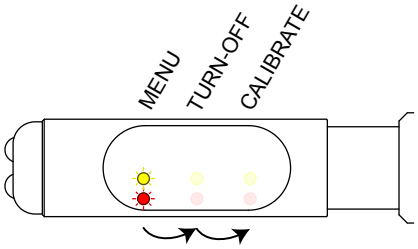
Entering Commands: Connect wet contacts using damp cloth (recommended), wet finger, or metal coin.

Turning On: Hold wet contacts for 5 seconds.

Basic Commands: Enter commands as follows:

1. Double tap to select column.
2. Hold for 3 seconds.
3. LEDs blink twice to confirm. The wet contacts must be released during these blinks or the command is ignored.
4. Command executes.

BASIC COMMANDS



Each double tap advances one column

MENU: Execute this command three times to enter the Advanced Options (see below).

TURN-OFF: Turn-off to save power. HUD will auto shutdown if not wet for 30 minutes.

CALIBRATE: Execute this command to perform PPO2 calibration. Calibrates to a PPO2 of 1.0 absolute atmospheres(ata)/bar. i.e. assumes 100% O2 at sea-level. Unplug HUD and use alternate handset (e.g. Petrel) for high-altitude calibration.

Advanced Options:

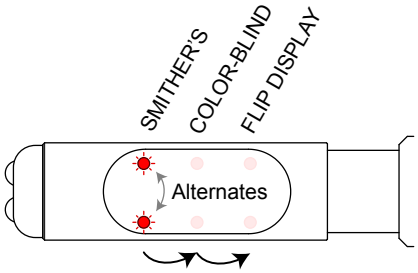
Enter Advanced Options by executing MENU command 3 times (see above). Double tap to select. Hold 3 seconds to confirm.

SMITHER'S: Default Smither's code blink pattern.

COLOR-BLIND: Optional blink pattern that does not require color to determine PPO2.

FLIP DISPLAY: Allows mounting HUD on either side of rebreather mouthpiece.

ADVANCED OPTIONS



Each double tap advances one column

Troubleshooting:

Use damp (not soaking wet) cloth for command entry. Sometimes a water droplet can cling between the wet contacts. A damp cloth does the best job of clearing this droplet between taps.

A double tap should take about one second. Too fast or too slow is ignored.

Remember to release wet contacts during the two confirmation blinks, or else command ignored.

Commands and PPO2 display backwards? Try turning HUD upside down, then use flip option.

Dry the wet contacts and turn-off when not in use to conserve battery power.

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